

Analysis of Bio-battery Making from Avocado Peel as an Alternative Practicum Design to Develop Pancasila Student Profile Character

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Abstract. The renewal of the curriculum from 2013 to the Merdeka curriculum emphasizes the importance of developing the characteristics of the Pancasila Student Profile in education through project-based learning, such as practicums. However, practicums on voltaic cell material often use expensive kits, while there is an alternative using bio-battery media from avocado peel waste, which is more environmentally friendly and economical. This research aims to utilize avocado peel waste as a substitute for commercial batteries, in the hope of reducing battery waste and providing an environmentally friendly and inexpensive practicum design, as well as building the characteristics of the pancasila student profile. The type of research used is descriptive qualitative, consisting of literature study, experimentation, and interview stages. The results showed variations in voltage and current strength produced by avocado peel bio-batteries depending on the variety of avocado peel and the length of fermentation time. Although the variation in avocado peel variety does not result in a significant difference, the electrical energy produced shows the potential of using this practicum in improving students' understanding and building the characteristics of the pancasila student profile.

Keywords: bio-battery, avocado peel, Pancasila student profile, voltaic cell, practicum

Introduction

The Ministry of Education and Culture made innovations in the field of education by changing the 2013 curriculum policy to an merdeka curriculum (Kenanga et al., 2022). Renewal of the national education system is inevitable and must be carried out and adjusted to the needs so as to ensure equitable distribution of education and improve the quality of students (Wati et al., 2023). The merdeka curriculum is focused on implementing projects to improve students' understanding of Pancasila values and create a pleasant learning environment (Susanti et al., 2023). In project-based learning, teachers are required to be able to become facilitators for students in order to realize students with character in accordance with the pancasila student profile (Wijayanti et al., 2022). One of the implementations of project-based learning is through practical activities such as practicum (Suryani et al., 2023). Practical activities will provide hands-on learning experiences and can build the characteristics of the Pancasila student profile, especially in

terms of cooperation, objectivity, critical reasoning, and innovation (Susanti et Al., 2023; Ahmad & Fikroh, 2023).

Practical activities will allow students to use their theoretical understanding in more depth and use their basic skills (Puspitasari et al., 2014). Students can directly observe the scientific process and identify and solve problems using the scientific method (Kurniawati et al., 2015). The use of practicum activities in the learning process allows teachers to see students' skills including science process skills (Maison et al., 2019). The application of learning methods with practicum methods can improve critical thinking skills, factual and procedural knowledge, and student understanding of chemistry learning, one of which is on voltaic cell sub-material (Zahroh, 2020; Xu & Talanquew, 2013; Rahimah, 2020). A study conducted by Wulandari (2014) on grade XI high school students showed an increase in science skills and concept mastery through the application of practicum-based learning. The research result of Rakhmawan et al. (2015) show that students' science skills can be improved through inquiry-based laboratory learning on voltaic cell sub-material in class XII SMA. According to Yanasari & Refelita (2017) practicum activities on voltaic cell sub-materials in schools still use practicum kits by utilizing commercial batteries. These batteries have several disadvantages, namely that they are not environmentally friendly, expensive, and contain many heavy metals (Fadilah & Rahmawati, 2015).

The use of batteries is not only in practicum activities at school but also often in daily activities (Dewi et al., 2021). Batteries that have been used will be thrown away because the type of battery used is a disposable dry battery (Nurannisa et al., 2021). The discarded batteries contain mercury, manganese, nickel lead, and cadmium which can damage the environment and are harmful to human health (Santoso & Halomoan, 2022). According to Purwati & Harjono (2017), battery waste also includes hazardous and toxic material (B3) waste, so proper processing techniques are needed including recycling. In addition, the increasing need for energy sources has resulted in the need for alternative energy to minimize energy sources running out (Masthura & Abdullah, 2021).

The development of alternative energy bio-batteries as a substitute for commercial batteries has been carried out by many researchers (Pamungkas, 2017). According to Siddiqui & Pathrikar (2013), the manufacture of bio-batteries was carried out to respond to public unrest about the impact of battery waste which is harmful to the environment. Many bio-battery developments are carried out using organic materials that are safe for the environment and there are no chemicals and the price is economical (Asharo et al., 2022). Organic waste such as vegetables and fruits contains minerals, sodium, potassium, magnesium, and carbonic acid that can conduct electricity so that it can be utilized as a bio-battery (Agustina et al., 2018; Setyowati, 2020). In addition, fruit and vegetable/food waste can be used as a source of electricity because it has a high level of acidity, which can generate electricity through a chemical process called fermentation (Fatimah et al., 2023; Fauzia et al., 2019). Another study was also conducted by Hendri et al. (2015) on the manufacture of bio-batteries from banana peels and the results showed that the best electricity-producing banana peels were found in ambon banana peels with a voltage of 3.70 volts and a current strength of 33.08 mA. The research results conducted by Muhlisin et al. (2015) state that banana peels and durian peels can be used as a battery substitute because they contain potassium, sodium, calcium, magnesium, and phosphorus substances that can carry positive and negative ions. Mineral compounds that can conduct electricity are found in other organic waste, namely avocado peels (Marianti et al., 2021).

Avocado peel can be utilized as a bio-battery because it contains mineral substances consisting of calcium, selenium, potassium, sodium, magnesium, phosphorus, and iron (Marianti et al., 2021; Vinha et al., 2020). The mineral content in avocado peel acts as an electrolyte so that it can convert chemical reactions into electrical energy (Masthura & Abdullah, 2021). Research conducted by Marianti et al. (2021) gave the result that avocado

peel produced electrical energy in a battery with a voltage of 11.23 volts after a fermentation time of 120 hours.

Research on the manufacture of bio-batteries from organic waste has been done a lot, but the avocado peel research itself has not been done much and has not been used as a practicum design. The results of interviews conducted with two high school chemistry teachers in Yogyakarta in December 2022 stated that practicum had not been carried out on voltaic cell sub-material due to limited materials and tools, and the price was expensive. Therefore, researchers researched the analysis of avocado peel as a battery substitute as an easy and cheap alternative practicum design in learning voltaic cell sub-material in class XII SMA. Students can also get an idea of how to utilize avocado peel waste which was previously only thrown away but with this research avocado peel waste can be utilized.

This research focused on the utilization of avocado peel waste as a battery substitute by utilizing organic materials (bio-battery). The novelty of this research is (1) the use of avocado peel as a bio-battery with testing media in commercial batteries, (2) variations in the fermentation time of avocado peel paste in bio-batteries, (3) the use of bio-battery practicum designs as a medium for building the character of the Pancasila Student Profile at school. The utilization of avocado peel was expected to reduce commercial battery waste and be used as a cheap and simple practicum design and build the character of the Pancasila Student Profile of SMA class XII students, namely cooperation, objectivity, critical reasoning, and innovation in learning voltaic cell sub-material.

Methods

This research uses descriptive qualitative research. Qualitative research is a type of research whose findings are not obtained from statistical procedures or other calculations (Strauss & Corbin, 2013). Qualitative research aims to describe the object of research, reveal the meaning behind the phenomenon, and explain the phenomenon that occurs. Thus, qualitative research was employed to find and described the activities and consequences of actions carried out narratively.

The data collection technique used is data triangulation, which means that it is carried out through several data collection techniques, namely literature study activities, experiments in making bio-batteries from avocado peel and interviews. Literature studies are carried out to analyze the curriculum. The experimental stage was carried out with the aim of examining or observing the process of making bio-batteries and as an alternative to simple practicum sub voltaic cell material. While the interview stage aims to see the suitability of practicum design with the character profile of Pancasila students.

The data analysis technique in this study used inductive qualitative analysis, namely analysis based on the data obtained, then developed a certain relationship pattern. The steps of qualitative data analysis in this study are data collection, data reduction, data presentation, and conclusion drawing (Rijali, 2019). Data were collected from primary sources and documented in the form of writing or audio recordings. Data reduction was carried out by rigorously selecting data, making summaries or brief descriptions, and grouping them into broader patterns. Data presentation was done in the form of narrative text such as field notes, tables, and charts. Drawing conclusions is the final stage in data analysis, which makes the data more detailed.

The process of analyzing the curriculum and the profile of Pancasila students uses the literature study method of voltaic cell sub-material. The literature study was carried out using the Merdeka curriculum text. The literature study was carried out with the aim of analyzing the contents of the Merdeka curriculum, especially the Pancasila Student Profile section of chemistry learning in schools. The important things found in the

curriculum text are then matched with the chemistry learning of the voltaic cell sub-material. The process of collecting data regarding the practicum design for making bio-batteries is carried out through experimental activities in the form of practicum. The manufacture of bio-batteries is carried out using several tools, namely a blender, multimeter, scissors, and knife. The materials used are 1.5 volt D type used batteries and avocado peel waste.

The practical activity step starts with making the bio-battery paste. Avocado peels were cleaned from the remaining pulp and washed with water. The avocado peel was divided into two to make two samples: dry avocado peel and fresh avocado peel. Then, some of the avocado peel is dried in an open room for one day until brownish in color. Each avocado peel sample is then mashed using a blender to form a paste. Avocado peel samples were fermented for 5 days, 10 days, and 15 days in an airtight container at room temperature. When the manufacture of the bio-battery paste is complete, the battery carbon is replaced with the bio-battery paste. An unused battery had its outer layer removed and the carbon rod removed. The carbon powder of the battery was removed thoroughly. The battery was cleaned and avocado peel paste was inserted into the battery until the battery was fully charged. The battery Cu electrode rod is placed back in the center of the battery. Batteries that already contain avocado peel paste are tested using a digital multimeter to determine the magnitude and strength of the electric current.

The suitability of the practicum design for making bio-batteries from avocado peel in learning voltaic cell sub-material with the character profile of Pancasila students was carried out by interviewing two chemistry teachers and 10 SMA/MA students. The interview results obtained will be used to determine the suitability of the practicum design for making bio-batteries from avocado peel with the character profile of pancasila students. The following is Figure 1 bio-battery design from avocado peel with different variations of fermentation time, and Figure 2 bio-battery testing design with a digital multimeter.

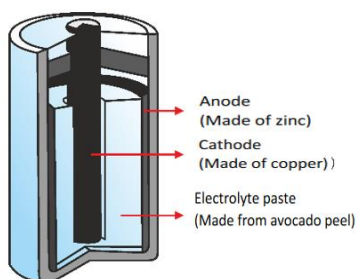


Figure 1. Avocado Peel Bio-Battery Design



Figure 2. Bio-battery Testing Circuit Design

Results and Discussion

The preliminary study for making bio-batteries from avocado peel waste was conducted to develop an initial procedure. The trial stage was also carried out to obtain a practicum procedure that was appropriate and easy for high school students to do. This trial was conducted using several variables, namely the type of avocado peel and variations in the length of fermentation time. The practicum procedure used is a procedure obtained from the results of a literature study of bio-battery making journals.

Curriculum Analysis and profile of Pancasila students

The process of analyzing the curriculum and the Pancasila Student Profile was carried out using the literature study method with a focus on the voltaic cell sub-material. This literature study uses the merdeka curriculum text which is accessed directly from the official website of the Ministry of Education and Culture at <https://ditpsd.kemdikbud.go.id/>. This analysis aims to understand the extent to which the merdeka curriculum supports the development of student character and competencies in accordance with the pancasila student profile.

Literature study is an important step in curriculum analysis because it allows researchers to understand the context and content of the curriculum in depth. By conducting a literature study, researchers can ensure that the learning methods and materials taught are in accordance with the stated educational objectives (Hidayah & Fikroh, 2023). Curriculum analysis includes understanding curriculum content, learning standards, and student competencies. Achievement indicators are used to design practicums that measure student competencies concretely (Ahmad & Fikroh, 2023). This analysis is used to ensure the practicum is in line with student needs and learning objectives. The relevance of practicum design with the pancasila student profile is contained in Table 1.

Table 1. Relevance of Practicum Design to Profile of Pancasila Students

Practicum Phase	Learning Indicator	Profile of Pancasila Students
Practicum on making bio-battery from avocado peels	Understand the basic concepts of voltaic cells and their reactions	Critical reasoning, mutual cooperation, innovation, creativity, objectivity
Analysis electrical test results	Analyzing the results of electrical tests produced by bio-batteries from avocado peels	
Use of voltaic cell principle in daily life	Identify applications of voltaic cells in everyday life	

Experiment Design for the Manufacture of Bio-battery from Avocado Peels

Bio-battery made from fermented avocado peel paste is able to produce voltage and strong electric current. The cathode of the bio-battery uses a cylindrical Cu electrode and the Zn electrode comes from a zinc battery. A zinc battery is also used as a medium to test the electrical character of avocado peel paste using a digital multimeter. Avocado peel fermentation is carried out directly without any additional microorganisms in it.

Fermentation is carried out with several time variations, namely 5 days, 10 days, and 15 days in an airtight container and at room temperature. The avocado peel bio-battery test media is shown in Figure 3. Figure 3. (a) shows a cylindrical copper (Cu) battery, (b) shows seg (Zn) test media, and (c) shows zinc (Zn) test media that has been filled with fermented avocado peel paste.

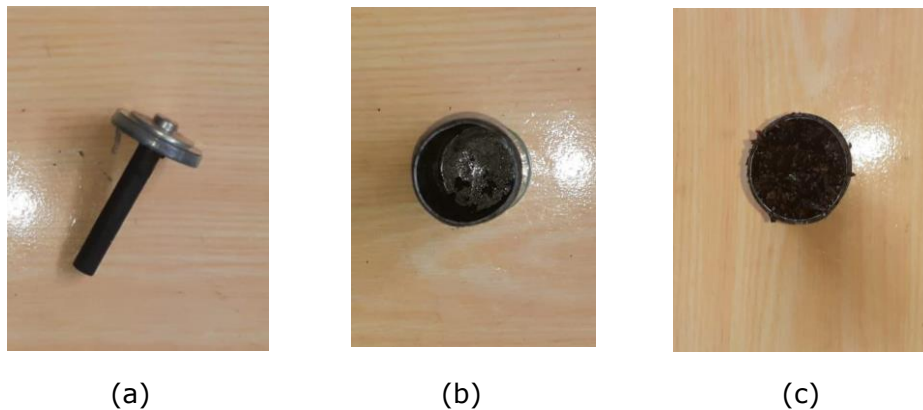


Figure 3. Avocado Peel Bio-Battery Test Media

Implementation of Bio-battery Feasibility from Avocado Peel

Electrical Test

1. Avocado Peel Electric Voltage Measurement Results

Based on the results of the avocado peel bio-battery electrical voltage research, the measurement data is obtained in Table 1.

Table 2. Measurement Results of Electrical Voltage of Each Avocado Skin Bio-battery

Sample	Fermentation Time (Days)	Electrical Voltage (Volts)
Dried Avocado Peel	5	0.92
	10	0.85
	15	0.77
Fresh Avocado Peel	5	0.99
	10	0.81
	15	0.79

From Table 2, it can be seen that in the measurements of each battery with different sample types and variations in fermentation time, the highest voltage is obtained in the alkaline avocado peel sample with a fermentation time of 5 days and the lowest voltage in the dry avocado peel sample with a fermentation time of 15 days. The amount of current strength of the two samples produced is not significantly different. Therefore, it can be seen that the type of avocado peel sample used does not have a significant effect on the amount of electric voltage. In addition, the results of the electric voltage obtained decreased with the length of fermentation time. The decrease in voltage can be seen in Figure 4.

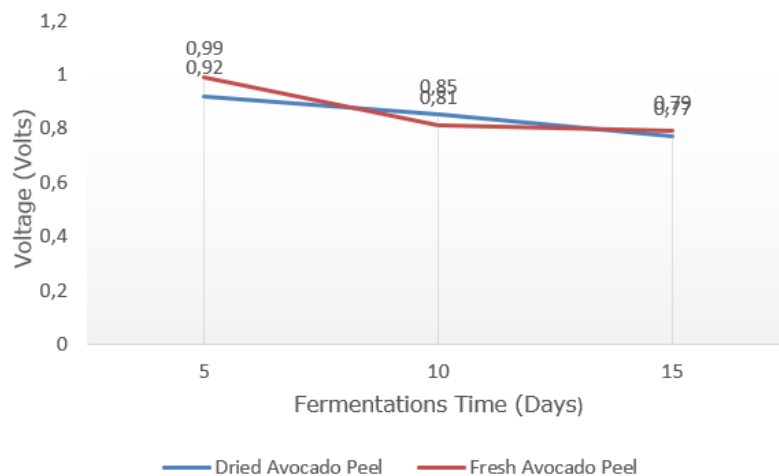


Figure 4. Voltage relationship graph of avocado peel bio-battery with fermentation time

2. Measurement Results of Strong Electric Current of Avocado Peel Bio-Battery

Based on the results of research on the electric current strength of avocado peel bio-batteries, the measurement data are obtained in Table 2.

Table 3. Measurement Results of Electric Current Strength of Each Avocado Peel Bio-battery

Sample	Fermentation Time (Days)	Strong Electric Current (A)
Dried Avocado Peel	5	0.43
	10	0.35
	15	0.09
Fresh Avocado Peel	5	0.56
	10	0.18
	15	0.17

In dry avocado peel, there is a decrease in the current strength value along with an increase in fermentation time. The highest current strength value occurred on day 5 fermentation 0.43 A. In wet avocado peel, the pattern of changes in current strength also varies. The highest current strength value occurred on day 5 0.56 A. The largest and smallest sample current strengths in both samples showed the same fermentation time, namely day 5 and day 15. The current strength of the two samples is not significantly different. Therefore, it can be seen that the different types of dried or fresh avocado peel samples do not really affect the current strength of the bio-battery, but the increase in fermentation time affects the current strength produced.

The amount of current strength in dry avocado peel or fresh avocado peel decreases with increasing fermentation time. Based on the measurement of current strength, a graph of the relationship between avocado peel samples and variations in fermentation time is obtained as in Figure 5 which shows that the current strength is inversely proportional to the fermentation time. The longer the fermentation time is carried out, the smaller the current strength produced by dry avocado peel bio-batteries and fresh avocado peel.

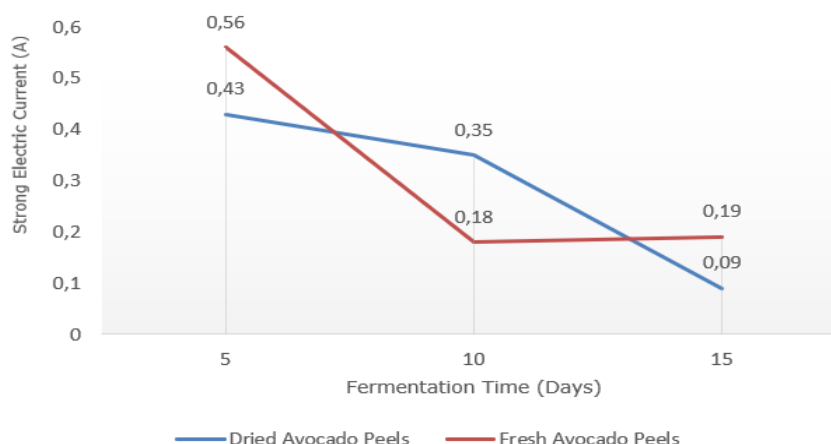


Figure 5. Relationship graph of avocado peel bio-battery current strength with fermentation time

The manufacture of bio-batteries in this study uses a fermentation process. Fermentation is the process of decomposing organic matter by microorganisms that produce products such as organic acids, alcohol, and gas (Fatimah et al., 2023). Carbohydrates contain glucose which, when mixed with water and left for several days, will undergo fermentation to produce ethanol, which is then oxidized to acetic acid (Muhlisin et al., 2015). Acetic acid is a type of electrolyte. The fermentation process also causes the pH value to drop increasingly acidic due to the formation of nitrogen and ammonia. The long fermentation time causes the electrical conductivity to increase because the solution will be more acidic. In a solution if the H^+ ions in the liquid increase, the OH^- ions will decrease and the H^+ ions move easily in the solution so that the electrical conductivity increases (Marianti et al., 2021).

In contrast to the results of research conducted by Marianti et al. (2021), the voltage and current strength in this study tended to decrease as the fermentation time increased. This can occur because during the measurement process the fermented avocado peel paste is exposed to oxygen so that an oxidation process occurs where hydrogen ions (H^+) are released (Yolanda, 2021). Hydrogen ions (H^+) act as acidic carrier ions so that if they are released, the acidity level of avocado peel paste decreases (Suciyati et al., 2019). In addition, the process of charging the battery with avocado peel paste can cause the entry or trapping of oxygen in the battery, affecting battery performance. This is in accordance with the research of Satriady et al. (2016) which states that oxygen in the battery will affect electrochemical reactions, inhibit the rate of ion diffusion and intercalation processes which will have an impact on reducing battery performance.

A decrease in the acidity of avocado peel paste will also affect the results of voltage and current measurements. The oxidation process also causes the density of electrically charged ions to decrease (Salafa et al., 2020). This can occur because the amount of oxygen is increasing so that the process of delivering electric current at the electrode is increasingly difficult (Suciyati et al., 2019). In addition, oxidation also causes corrosion of the zinc (Zn) electrode metal used so that it affects the voltage value and current strength (Muhlisin et al., 2015). The corrosion process causes the smaller voltage and current produced (Salafa et al., 2020). According to Sugianto & Lubis (2017), battery capacity can decrease if the electrolyte conditions begin to deteriorate such as battery poles experiencing corrosion due to electrolytes that are increasingly acidic, temperatures that are too high and batteries often experience discharge or charging.

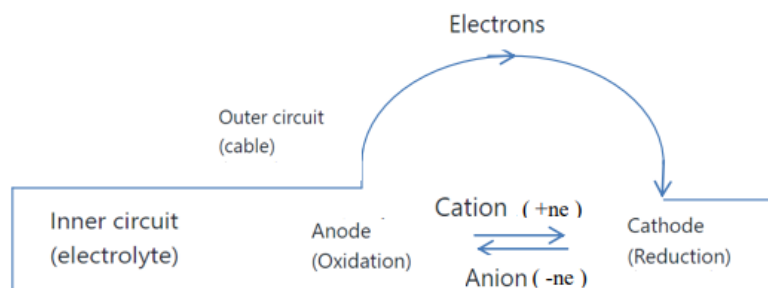


Figure 6. Direction of electrons from ions in a voltaic cell (Hiskia, 1992)

Based on Figure 6, the working principle of bio-batteries is based on electrochemistry, utilizing the reduction-oxidation process. The negative electrode (anode) undergoes an oxidation reaction, releasing electrons which are then carried by electrolyte ions to the positive electrode (cathode) (Fauzia et al., 2019). This transfer of electrons by electrolyte ions produces a voltage difference and electric current when connected to electronic components such as diodes, resistors, or capacitors (Frenzel, 2017). These electrons flow through the outer circuit to the cathode and switch to the substance in the electrolyte, causing the substance to undergo reduction. In the electrolyte (internal circuit), charges are transported by cations to the cathode and by anions to the anode. This process will take place repeatedly so as to produce electrical energy (Hiskia, 1992). Avocado peel contains electrolyte substances that will flow to the cathode by cations and to the anode by anions so as to produce electrical energy. Electrolytes contained in avocado peel are calcium, potassium, sodium, magnesium, phosphorus, and iron (Marianti et al., 2021). The total levels of electrolytes in avocado peel are potassium 1166 mg/100 g, magnesium 67 mg/100 g, calcium 30 mg/100 g, and sodium 18 mg/100 g (Karina, 2012).

Aspects of Suitability of Practicum Design

The suitability of practicum design with the character profile of pancasila students can be known through interviews with 2 chemistry teachers and 10 SMA/MA students. Based on the interviews conducted, this practicum design can be said to be in accordance with the character profile of pancasila students, especially in phase F (Class XII) which consists of cooperation, objectivity, critical thinking, and innovation.

In this practicum, students need to work together in groups to achieve a common goal, which is to make a bio-battery from avocado peel. Through this practicum activity of making bio-batteries, students need to share tasks, discuss, and help each other in completing each stage. This teaches them the important value of cooperation in achieving a common goal, in line with the spirit of mutual cooperation reflected in Pancasila (Aries, 2022). This practicum will also train students' objective attitude because students must be able to distinguish between facts and prejudices, and assess the experimental results objectively based on the data that has been collected (Patmawati, 2011). The problem-solving process involved in this practicum also stimulates students' critical thinking in finding solutions (Masek & Yamin, 2011). Students need to identify problems that arise during the practicum, gather information, evaluate solution options, and choose the best solution based on critical reasoning. In addition, with practicum using simple materials such as avocado peel, students are encouraged to think innovatively. Students are invited to design bio-batteries from unused materials as a substitute for commercial batteries that harm the environment so that students can develop creativity and innovation according to their thinking to find new solutions to solve problems.

The research that has been carried out shows that avocado peel can function as a bio-battery because it produces electrical energy based on the voltage and current strength produced. The process of making bio-batteries using avocado peel does not require complicated tools and does not require large costs. The tools and materials used can be found in everyday life. In addition, the simple manufacturing procedure is easy for high school students to practice at school. This practicum design is stated to have the potential to build the character profile of Pancasila students, namely the ability to cooperate, objectivity, critical thinking, and innovation. The existence of this practicum design is expected that students can also understand how to utilize avocado peel waste and commercial battery waste which is often considered to have no value. Thus, the use of avocado peel as a bio-battery material will not only improve students' learning abilities and experiences, but can also make a positive contribution to creating sustainability in daily life.

Conclusion

Based on the results of research and discussion, it was concluded that there were differences in voltage and current strength produced by avocado peel bio-batteries based on variations in avocado peel type and length of fermentation time. Variations in the type of avocado peel did not provide significant differences because the voltage and current strength of each sample had a small difference. The best voltage and current strength results were obtained at a fermentation time of 5 days for each type of avocado peel, with dry avocado peel producing 0.92 Volts and 0.43 A, and fresh avocado peel producing 0.99 Volts and 0.53 A. The amount of voltage and current strength showed an inversely proportional relationship with the length of fermentation time, where both tended to decrease as the increased. The presence of electrical energy produced by avocado peel bio-batteries showed that making bio-batteries from avocado peel could be used as an alternative for cheap and simple practicum designs for high school students to improve understanding in learning the chemistry of voltaic cells.

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